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# UML Based Modeling for Data Aggregation in Secured Wireless Sensor Network

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**Abstract**

Up till now, less research has been done in developing a Wireless Sensor Network (WSN) data aggregation with the help of Object OrientedModeling and Design (OOMD). These kinds of applicationincludeuse of complex data structures and different algorithms for aggregating data. Usually for such calculation, mathematical modeling is done. To visually represent any research problems,Unified Modeling Language (UML)is more efficient tool for modeling. In this paper, demonstration of UML diagrams is presented for modeling of data aggregation in WSN which leads to better development of application.As a result of additional sensor nodes being deployed in the wireless sensor networks, demand on resource constraints is reduced, whichleads to increase in redundantdata. Data aggregation protocol helps to reduce this redundancy by organizing the data efficiently. Due to the constraints on energy in the WSNs, Use of data aggregation techniques and data dissemination across WSN plays an significant role in the network life cycle time as they help to conserve the energy of sensor nodes.In this, data is collected by sensor node, then dedicated cluster node aggregates it with data aggregation algorithm and then it is forwarded to base station.This flow of various activities is modeled using UML diagrams. Heresystem is analyzed withhelp of use case diagram, class diagram, sequencediagram, collaborationdiagram and activity diagram. Modeling this kind of problems using UML approach helps to visualize, specify ,construct and document the system artifact effectively which is helpful for various stakeholders of the application.


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## 1. Introduction

WSN has small sensor nodes also called as motes.It has various capabilities like information sensing, computation,high-speed communication and result generation. In various application sensors are deployed and they collect environment information (for example temperature, humidity) from all sensors which is in turn send to the base station. WSN generates a huge data which need to be aggregated at various different levels. To examine the performance of a sensor network, bandwidth,signal strength, memory, battery power etc. have been utilized; its efficiency can be improved by reducing the cost of cluster development.The basic requirement and challenge of data gathering task is sensor energy conservation so that its lifetime is increased.

Modeling activity is atcentre of Software Development Life Cycle (SDLC)which leads to better application development and reusability. The Unified Modeling Language (UML) is a graphical language which is effective for visualization, specification, construction, and documentationof a software-intensive system's artifact. The UML provides a standardpracticesfor writing a blueprint of system. It coversvarious conceptual things, such as system functionality through use cases and business processes.It also covers concrete things like database schema, reusable component, classes which are written in a specific programming language[1]. This paper mainly focuses on how to follow and apply process of formal development with UML in WSN data aggregation which is based on the OOMD.

## 2. Related Work

FengyuanRen[2]proposed Attribute-aware data aggregation (ADA) scheme.It uses packet-driven timing algorithm and potential-based dynamic routing method (PSDR)with packet attribute. Guorui Li[3]proposed data aggregation based on temporal correlation using Auto Regressive moving average (ARIMA). Enam, R.N [4]proposedData Aggregation based on Energy Efficient Differential in a Dynamic Cluster Based WSN. She proposed virtual grid algorithmusing clustering mechanism. Hemant Sethi[5]proposed an Energy Efficient Interest Based Reliable Data Aggregation (EIRDA) Protocol for WSNs. Here each cluster considers the uniform distribution of sensor nodes using EIRDA which is a static in nature.Ren P. Liu[6] proposed an Efficient Reliable Data Collection (eRDC) algorithm. Implementation of eRDCuses hop numbers and quality of next hop link for findingtotal number of re-transmissions.Basavaraj S. Mathapati[7]proposed an Energy Efficient Reliable Data Aggregation Technique for WSN. Bala Krishna [8] proposed energy efficient data aggregation technique in WSN using a novel approach which classify the energy efficient data aggregation protocols based on structure, search-based and time-based approaches. Sumit Chaudhary [9] have proposed the effective and efficient mechanism and architecture of energy efficient techniques for data aggregation and collection in WSN using principles like global weight calculation of nodes, data collection for cluster head and data aggregation techniques using data cube aggregation. They have modeled data collection technique with one UML diagram.

## 3. UML Applications in various domains

The UML effort started in October 1994officially with fusionof Booch, Jacobson's OOSE (Object-Oriented Software Engineering), and Rumbaugh's OMT (Object Modeling Technique) approach. After its introduction, UML has beenuniversally adapted and used by the community of software development.It is because of models help to depict graphically, specifying, constructing, and documenting the artifacts of a software-intensive system.

It facilitates comprehensible modeling techniques to describe system models and used for various applications, ranging from engineering modeling tobusiness processes, mainly for documentation purposes.

Nilesh J. Uke [10]illustrates an effective solution to modeling object tracking in video using UML diagrams. Various modules like shot segmentation, feature extraction, and object tracking are integrated for detection of moving objects from video. It is modeled using UML diagram. Infantino et al [11]demonstrates use of UML in mechatronic to validate andverify the conceptual robot design. Shi-xiang& Wang [12]used UML Profile which allows capturing software perspective of CPS (Cyber Physical Systems) applications.

Gavrilescu et al [13] demonstratesuse of UMLfor modeling distributed and parallel applications by usingactivity diagrams, class diagrams and collaboration diagram.Test benchuse cases were proposed by Evans &Wellings[14]which helps for analyzing requirement of customer in train control system as significant part of high-speed railway.Yuan et al. [15] proposed state chart and Activity diagrams to describe a modeling technique for adaptable, independent production agents, which are used for the decentralization of production management systems. They used state models for depicting the real time behavior of the production agents. Kim and Baek [16]proposed design by using UMLfor fault management with Telecommunications Management Network (TMN) based on Quality Assurance Process Model(QAPM) intelecommunications applications.

## 4. Object oriented development using UML

Data aggregation task in WSN often contains complex data structures and numerical calculations.Baresi et al. [17]proposed mathematical model for modeling such numerical calculations. Unified Modeling Language (UML) is used for algorithms with complex mathematical models and data models. The effortless and straightforward transition from design to implementation as well as forward engineering is one of reason for its ubiquitous popularity. The traditional approaches for software development like waterfall, prototyping,iterative,evolutionary,spiral, rapid application development (RAD) and agile by Muller et al [18] are not suitable for WSN applications.

The axiom which UML is based on is that the atomization of any system is possible into a group of collaborating entities and that many perspectives of these entities, their operations, features, constraint, interaction, states and packaging can be described using various UML diagrams: Class, Use Case, Object, Sequence, State Machine,Package, Activity, Component, Deployment, Composite Structure, Timing, Interaction Overview, Communication and Profile diagram[1].

The two main classes of UML diagrams are structural diagrams and behavior diagrams. Structural diagram shows the passivestructure of the system and behavior diagrams show the active behavior of the objects in a system as shown in Fig 1.

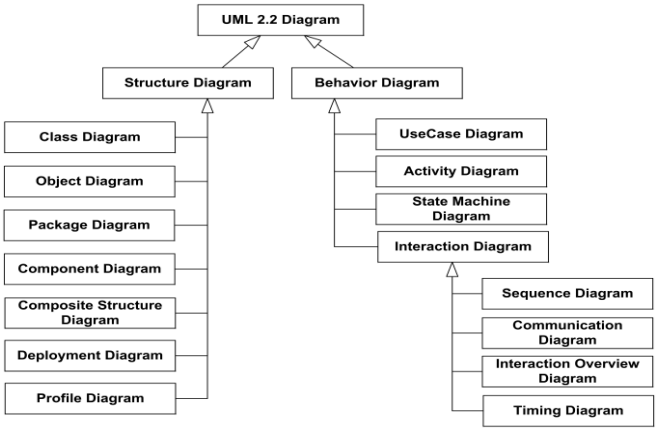


Fig. 1.Types of UML Diagram

Use case depicts the system behavior with a user's perspective. A class diagram demonstrates the anatomy of various classes and the relationships between the same. A state model demonstrates the behavior of a system to react to external events and signals in the form of machine states.Activity diagram models the flow of action from one object to another when an activity is being performed. A sequence diagram represents the interaction of objects while performing a function. A component diagram depicts a concrete aspect of the system. The deployment diagram shows the way a system is distributed with all its modules performing in the hardware environment. The

diagrams choice used to model various aspects of system is dependent on the type and intricacy complexity of the system. Certainly, we may not require all UML diagrams to illustrateeach aspect of the system.

## 5. Data Aggregation in WSN

Data aggregation is a process of aggregating the sensor data using aggregation algorithm. There are various types of aggregation techniques as listed below.

- Centralized Approach
- In-Network Aggregation
- Tree Based Approach
- Cluster Based Approach

This paper presents cluster based approach of data aggregation.

Practically sensors are distributed evenly in WSN.Here we will dividing the available area into fixed size clusters (grid clustering). We can have clusters in the number of Perfect Squares so that it will be easy to represent the clusters onto Simulator. Once clustering is done the cluster head is selected. Initially cluster head is selected randomly because each sensor node in the aggregated WSN has Equal energy. In each cluster every sensor node sends data to cluster head.

Procedure for selecting cluster head:

- First time when network is form the cluster head is selected randomly because every node in network has same energy.
- After some time interval energy level of cluster head is checked if energy level is less than 20 percentages then new cluster head is selected.
- Nodes that have been cluster heads cannot become cluster head again. The member node which has /highest energy level will become the cluster head in that cluster.
- Each node has a 1/P probability of becoming a cluster head in each round, where P is the desired percentage of cluster heads.
- At the end of each round, each node that is not a cluster head sends the data to its cluster head using shortest path to its cluster head.

Generally Cluster Head consume more amount of energy. So after some time its Energy gets reduced. Therefore it is necessary to Re-Elect the new cluster head. Hence as per LEACH algorithm after some iteration we will be electing a new Cluster Head based on their Energy value. Node with highest energy in the cluster will be elected as the cluster head.

We are using the average function for aggregating the Data Packets as shown in figure 2.

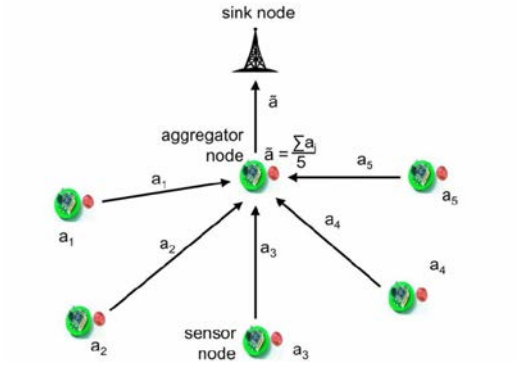


Fig. 2.Aggregation of Data in WSN

For sending the Data from Sensor to Cluster Head we will need to have a path. Here we will be needed to select the path with minimum distance or hop count to reduce the energy usage. So for finding the shortest path we will be using the Dijkstra Algorithm. We are using Pythagoras theorem for finding the distance between two sensor nodes.

## 6. Modeling data aggregation in WSN

UML diagrams are described in following section which expresses the formal process of data aggregation development based on the OOMD approach.

### *6.1. Class Diagram*

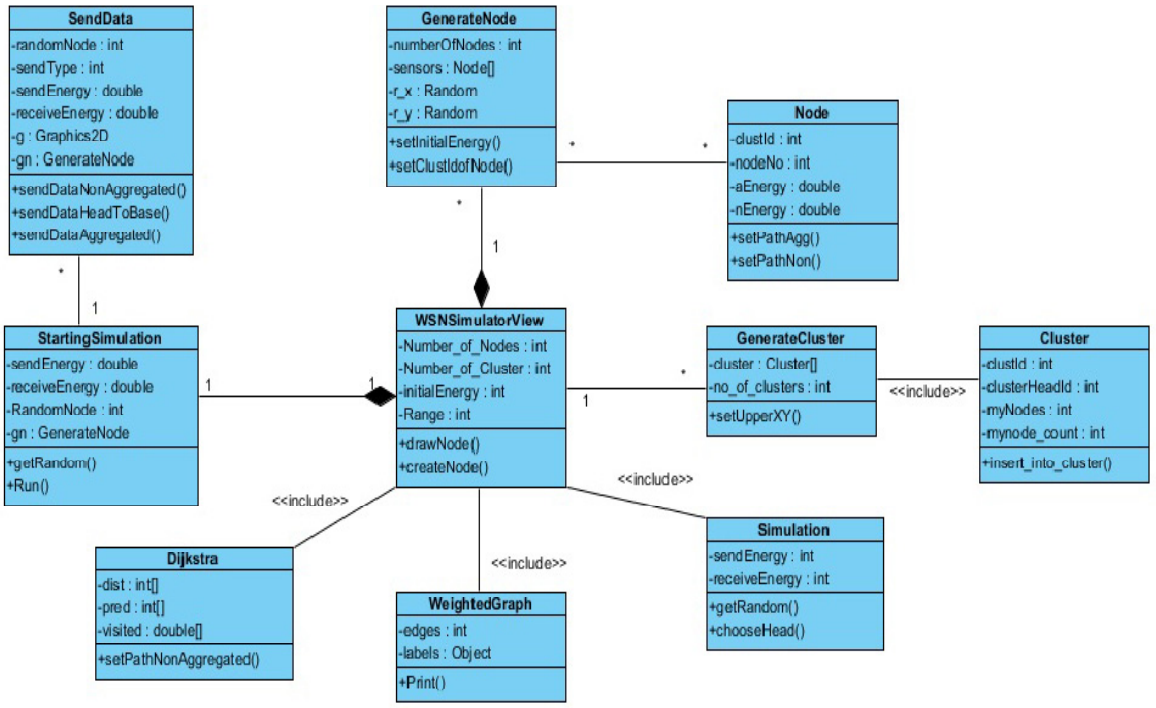


Fig. 3.Class Diagram.

As shown in figure 3, class WSNSimulatorView is the main class which has different data types and methods. The class Generate Node generates the sensor node and assigns all parameters for it. The class Dijkstra finds the shortest path from given source to destination in the form of minimum hop count. The class Cluster forms the cluster for aggregated WSN in the form of square grid, we can form clusters in perfect square number.

### *6.2. Use Case*

As shown in figure 4, there are three actors cluster head, member node, sink node. Every node has same functionality with some different functions of member node and cluster head. The member node will generate, send or receive data and it will find the shortest path to send the data. The cluster head will receive data from different member nodes and aggregate that data to send to the sink node. Cluster head also checks for its energy level. If energy level is less than defined standard then new cluster head will be selected. Sink node will disaggregate the received data and decrease its energy.

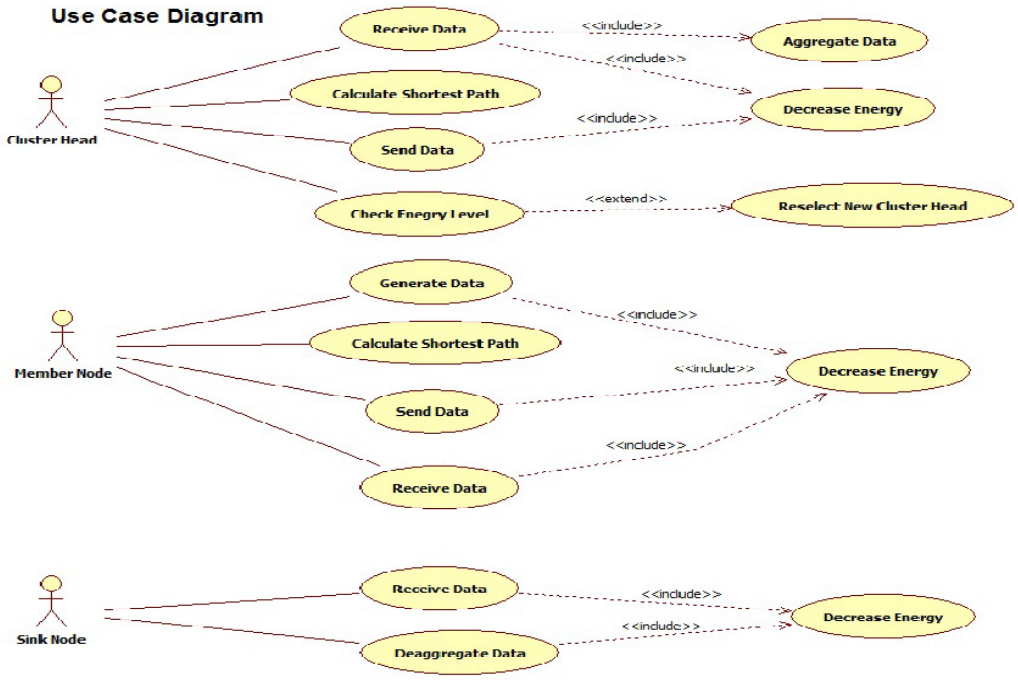


Fig. 4. Use case Diagram.

### *6.3. Activity Diagram*

As shown in figure 5(a) receiving data and generating data is parallel activity of member node. It finds shortest distance before sending data to cluster head or base station. As shown in figure 5(b), cluster head has different functionality than member node. Cluster head node will aggregate the data received from different member nodes and then send this aggregated data as per shortest path to base station.

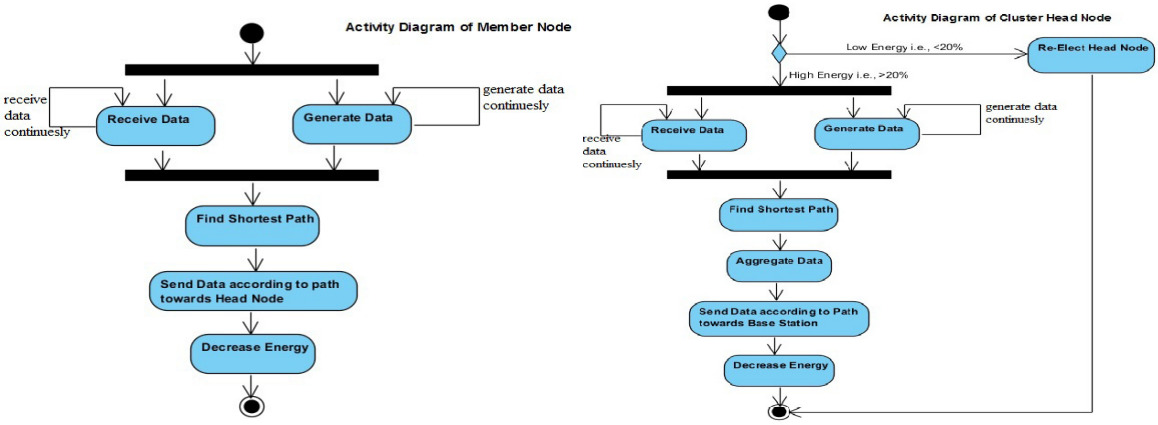


Fig. 5(a)Activity diagram of Member Node. (b)Activity diagram of Cluster Head Node

### *6.4. Sequence Diagram*

Figure 6 shows interaction between various objects over their lifeline. Here Alt combined fragment is used to show decision making based on energy level.

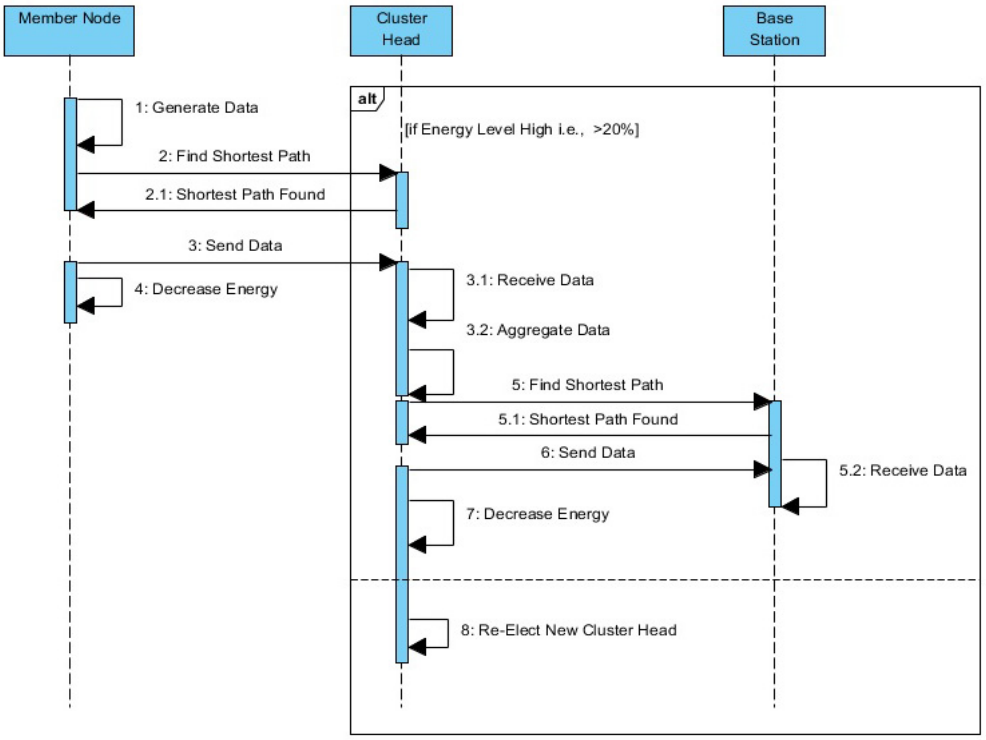


Fig 6. Sequence Diagram.

### *6.5. Collaboration Diagram*

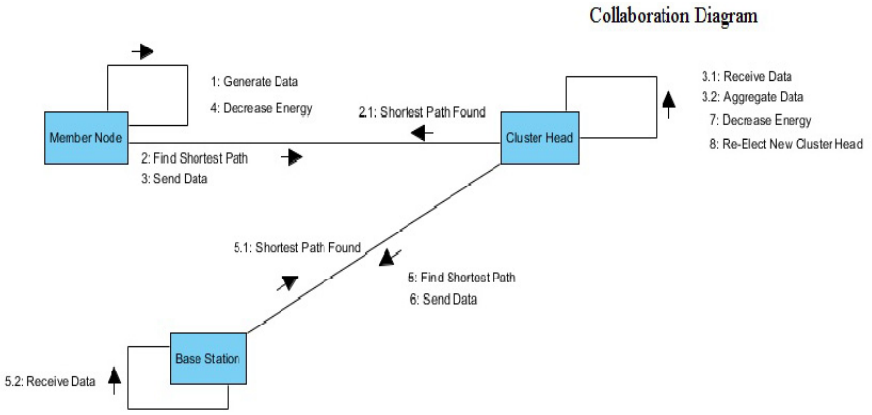


Fig7. Collaboration Diagram

The sequence of messages and objects are shown through a numbering scheme as shown in figure 7.

## 7. Conclusion

Formal approach of data aggregation in WSN is expressed in this paper by applying object oriented modeling approach and by using UML. The article describes the essential concepts of object oriented modeling and design. In general system design and development is done with UML approach. Then, we exhibit the use of UML diagramsi.e., class diagram, use case diagram, activity diagram, sequence diagram and communication diagram fordata aggregation starting from sensing data by sensor node, sending it to cluster head for aggregation and then aggregated data is send to basestation for. Efficient data aggregation not only offer energy conservation but also helps to remove redundant data and thus present only useful data for further analysis. We can divide the WSN application into limited and controllable modules with such modeling tools. It leads application development rapidly and efficiently.

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